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TECHNICAL REQUIREMENTS FOR NATIONAL ASSESSMENTS OF WILDLIFE AND FISH

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TECHNICAL REQUIREMENTS FOR NATIONAL ASSESSMENTS OF WILDLIFE AND FISH

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RPA Assessment

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National assessments describe the past, present, and future status of renewable natural resources. An important purpose of a national assessment is to document whether and how the nation's renewable natural resource production can meet future resource demands through a change in current land and resource management. A national assessment of wildlife and fish ideally should be carried out as an integral part of a broader natural resource assessment.

We interpret the Forest and Rangeland Renewable Resources Planning Act to define three renewable resource oriented requirements for a national assessment. The first requirement is to compile current and historical inventory information on wildlife and fish populations and habitat quantities and quality. The second requirement is to project current production and consumption into the future. The third requirement is to define opportunities for improving the future situation for wildlife and fish resources, considering tradeoffs in production for all renewable resources.

BACKGROUND

Recent federal legislation has focused attention on national assessments of renewable resources including wildlife and fish. The USDA Forest Service, responding to the requirements of the Forest and Rangeland Renewable Resources Planning Act (RPA) of 1974 (P.L. 93-378) has conducted national assessments in 1975 (USDA Forest Service 1977) and 1980 (USDA, Forest Service 1980). The procedures used to conduct the 1980 RPA Assessment of Wildlife and Fish (Schweitzer and Cushwa 1978), a progress report (Schweitzer, et al. 1978), a preliminary evaluation of the database (Hoekstra, et al. 1980) and lessons learned in carrying out the National RPA Assessment of Wildlife and Fish (Schweitzer, et al., 1981), provide additional perspective on the definition, requirements, difficulties, and successes of conducting a national assessment.

Other national evaluations of the wildlife and fish situation have been conducted to address specific issues or concerns about the resource. A National Appraisal of Fish and Wildlife Habitat was conducted by the USDA Soil Conservation Service in 1980 (USDA, SCS, 1980) in response to the Soil and Water Resources Conservation Act (RCA) of 1977 (P.L. 95-192). Other examples include the National Academy of Sciences (1970) report on Land Use and Wildlife Resources and the Council on Environmental Quality report (1978) of a National symposium on Wildlife of America.

National assessments prior to RPA and RCA did not require such comprehensive consideration of all three requirements and in particular the second and third requirements. To some extent, the definciencies of RPA and RCA assessments written to date are the result of an inability to incorporate wildlife and fish resources into production, consumption, and alternative opportunity analyses. Deficiencies continue to exist in analytical techniques and available data for accomplishing these requirements. The purpose of this paper is to define these three assessment requirements (I, II, III) as a conceptual framework that wildlife and fish resource specialists can use in developing improved analytical techniques and data.

I. HISTORICAL AND CURRENT LAND, WILDLIFE, AND FISH POPULATION AND HABITAT PRODUCTION CAPABILITY

Requirement one most closely follows the conventional preception of describing the status of wildlife and fish resources. National summaries of population and habitat inventory information have been and can continue to be presented through sorting and manipulation of inventory data files to address requirement one. However, as Hoekstra et al. (1980) have previously reported, the availability of consistent data for a nation wide assessment of wildlife

and fish exist only in part. This is true even after two RPA Assessments and one RCA Appraisal. Ideally, such data files would include a quantification of populations of wildlife and fish species and their habitat capability together with probable other renewable resource quantities associated with the same land areas. This information can be used as data for multiple-resource supply production analyses as well as compiled for national statistics on land, resource stocks, and production capabilities.

A framework for organizing inventory information is necessary. Analyses of joint resource production possibilities assume the production relationship of all renewable resources are valid. Given that these analyses may be performed at various levels of data aggregation, a fixed hierarchical geographic basis for compilation of information used in the national assessments is required.

A geographic hierarchy for organizing all inventory information about area, resource stocks, and supply production capability used in the national assessments is needed. It is important to maintain the spatial relationships between different resources, i.e., have a common definition of the land base. It is also important to know the context provided by the next higher level for each category of information. An additional purpose of a hierarchy is to establish a standard context for area, resource stocks, and supply production capability information within and between agencies. Levels in the hierarchy shown in Table 1 are suggested as one possible hierarchical framework.

Specific information on wildlife and fish in Table 1 are needed to express resource stock and land capability in terms of productivity and condition of wildlife and fish. Potential wildlife and fish habitat productivity permits calculation of a population level of an animal species that the habitat of that species is capable of producing as the result of a defined land management strategy on a particular land unit for a specified time period. Current habitat

Table 1.--Hierarchy for stratification of national assessment inventory information needed to answer questions on area and wildlife and fish population and habitat quantities for productivity and condition class.

Category	Type information Required	Common to all Resources	Unique to wildlife and Fish	Definition Reference
Political	State, County	X		GSA. 1965
Ecological	Ecosystem District	X		Bailey R.G, 1980
	WRC Subregion	X		US, WRC, 1978
Administrative	Ownership Class	X		Hoekstra et al. 1981
	Land Use Categories	X		USGS, 1976
	Legal or Administrative Categories	X		USDA, FS, 1980
Natural Potential Vegetation	Vegetation Series	X		Küchler, A. W. 1964
Current Ecological Status	Vegetation Cover Type	X		(no commonly accepted reference)
	Soil Family	X		USDA, SCS, 1975
	Water System	X		Cowardin et al., 1979
Habitat Productivity	Potential		X	Defined in this paper (page 4)
Habitat Condition	Current		X	Defined in this paper (page 4)

condition is described by the current population level of an animal species in that habitat as a result of a past land management strategy on a particular land unit. Ideally productivity and condition would be measured in kilograms/hectare of biomass, pragmatically however, numbers of animals will likely have to be used as a surrogate.

Other information in Table 1 is common to all resources and identifies a series of descriptors that permits cross-referencing other resource information. Expect for describing the current or historical situation, information identified in this table does not represent opportunities for potential land allocation for renewable resource production since this must be done in a multiple resource production analysis.

II. CONSUMPTION AND INVENTORY PROJECTION

The second requirement specifies prediction of the inventories and consumption of renewable resources at various times in the future, discussed separately below. This second requirement for a national assessment is a substantial increment beyond requirement one.

Consumption Projections.

For resources provided through a market, a traditional competitive market structure would be appropriate for projecting consumption. In such a structure, consumption would be interpretted as an equilibrium quantity demanded. Thus, projection of consumption would require projection of both a supply function and demand function to determine the equilibrium. An excellent example of this sort of projection model is the Timber Assessment Market Model (Adams and Haynes, 1980).

For resources that are predominately provided outside the market, a market simulation may not be a good predictor of consumption.* Under the traditional practice of nearly "free" provision of many wildlife and fish resources,

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*Traditional economic theory suggests that a perfectly competitive market system creates a Pareto efficient allocation of resources (Henderson and Quandt 1971). Thus, if a public agency wished to emulate such a market and correctly projected the entire market system, the resulting projections of quantity demanded would be "desirable" in an efficiency context. It must be pointed out, however, that in implementing plans based on these projections, either "equilibrium prices" would have to be charged or use would have to be restricted to equilibrium levels. Otherwise, excess demand or over-use is to be expected.

disequilibrium levels of quantity demanded (associated with disequilibrium prices) are to be expected. Furthermore, it is likely that nonprivate suppliers of wildlife and fish are not price-sensitive. If, in fact, provision of wildlife and fish resources is independent of price, then the supply function describing aggregate behavior is a verticle line (fixed quantity supplied), and the supply function describing the price that each consumer faces is a horizontal line (fixed price).

If this structure is realistically correct, the quantity demanded could be projected with knowledge of future exogenous price surrogates (nonequilibrium) and "demand shifters" (X_i), and independent of future quantities supplied. In the context of Pareto efficiency, the projected Q_d would be a meaningful result only if the price level substituted into the demand function is, in fact, the "correct" welfare-efficient price. In the competitive market structure, the bidding process of the market between suppliers and demanders determines, endogenously, the "correct" price. In this non-market good structure, however, the price does not enter the supply function, and no equilibrium system exists to define such a "correct" price.

It is concluded that projections of the quantity demanded without a "correct" price will not be useful in attempting to allocate the publicly produced resource efficiently. The purpose of projections is, therefore, limited to predicting and obviating future large-scale over-use of wildlife and fish resources.

For this purpose, the quantity demanded may not be the relevant variable to be projected. The quantity demanded, as traditionally defined, exists regardless of the actual opportunity to consume. In terms of obviating future over-use, the relevant variable would be actual expected consumption, which would be influenced by quantity supplied.

To project consumption, this indicates a structure such as:

$$Q_c = F(P, X_i, Q_p)$$

Where:

Q_c = the quantity of wildlife and fish resources actually consumed

P = a price surrogate, such as travel costs or time costs

X_i = the traditional "demand shifters"

Q_p = the quantity of wildlife and fish resources provided

The quantity produced affects the quantity consumed (Q_c) functionally, through a long-term disequilibrium. If a rigid set of use levels (per unit) were enforced for wildlife and fish resources, the Q_p might determine rather than affect Q_c. When this is the case, projections of Q_c are merely reflections of public decisions concerning Q_p. It would appear, however, that such rigid use intensity standards are enforced only for selected species such as bighorn sheep.

An important implication of this structure is that consumption levels are not independent of quantity supplied, even though quantity demanded may be. Thus, if a public agency is to use projections of Q_c to anticipate conjestion or overuse, then the impact of wildlife and fish development decisions must be taken into account. For a more detailed discussion of this approach applied to recreation resources, see Hof and Kaiser (in press).

It is worth repeating that such projections of consumption have no normative economic application--they are not consistent with conditions for economic efficiency. They are merely predictions of fixed-price, fixed-quantity-supplied disequilibria.

Inventory Projections

Current and historical inventories of wildlife and fish populations and their habitats provide information on past trends in these resource quantities. Analysis of factors, such as land use, that are correlated with these trends can assist in making projections of future inventories. Current and historical information are a matter of record in contrast to the projections of future inventories which are based on three broad classes of assumptions. Ecological assumptions concerning land capability, birth, growth, mortality, and management actions; economic assumptions on resource markets, resource harvests, income and employment; and social structure assumptions defining institutional variables are examples of factors that potentially influence inventory projections.

For resources provided through the public sector, such as the National Forests and Bureau of Land Management, inventory projections can be made through land and resource management planning activities. Ecological, economic, and socio-economic analysis used in land and resource management planning provide a projection of the resource inventory through an evaluation of future alternatives for managed units of land. This is discussed in detail in the technical requirements for a national assessment of multiresource interactions (Hof and Hoekstra, 1982).

Future resource inventories for private lands are generally not available from land and resource management plans. State and regional estimates of future resource inventories on private lands should be developed for different types of private ownerships due to differences in ownership objectives.

Models have been developed to project future wildlife and fish populations based on current numbers, sex and age ratios, natality, harvest, and mortality rates. Other models have projected future wildlife and fish populations based

on relationships to habitat (Hawkes et al., in press). Ideally population projections would be made using both population and habitat parameters; however, both analyses and data limit general application.

Prediction of wildlife and fish populations based on population size, structure, and dynamics is difficult and few techniques exist that can be applied to produce accurate and precise information for use nationwide. Many species do not lend themselves easily to direct population estimation due to mobility and behavioral characteristics (Miller, in press). Population estimates based on size, structure, and dynamic attributes of species populations are potential populations rather than actual populations. Potential populations developed on this basis lack relationship to current or future habitats and thereby are difficult to relate to land management activities.

Predictions of wildlife and fish populations based on habitat variables and habitat relationships can be classified by two approaches. In the first case, models of wildlife and fish habitats produce estimates of suitability for species (USFWS, 1980, Nelson and Salwasser, in press). Suitability indicies cannot be reliably converted to expected populations, however. The second approach uses multivariate statistical methods. The use of multivariate statistics in studies of wildlife habitat was the subject of a recent workshop (Capen, 1981). In this approach, environmental variables are analyzed for their correlation with observed changes in population levels (Klopatek and Kitchings, in press). Alternative future populations can be predicted based on different senerios about quantities of correlated environmental variables. Predictions of wildlife and fish populations are the basis for making national assessment resource production projections for nonfederal lands.

III. OPPORTUNITIES FOR IMPROVING THE FUTURE RENEWABLE RESOURCE SITUATION

This task is of a more prescriptive nature than the previous two tasks. Thus, it can provide the link between the Assessment and the Programs. That is, if the Assessment analysis is capable of determining opportunities for improving the future resource situation from some standpoint, then this provides the direction for the Program. Taking the RPA as a whole, together with subsequent legislation and administrative direction, it is concluded that information is needed concerning both benefits and costs, as well as a means of analyzing planning alternatives. These are discussed in more detail below.

Benefits

The benefits referred to here are subjective consumer valuations of outputs. Economic methodologies utilize willingness-to-pay to index these valuations. In this context then, these benefit measures are on the "demand side."

Analysis of these demand side benefits in functional analyses relies on an assumption that interactions between demand functions occur only within functional areas, and not between them. Thus, for example, it is assumed that different recreation facilities may be complements or substitutes, but recreation and timber products are not so related. If this assumption is empirically untenable, then benefit estimation must occur simultaneously (and not by individual resources) for the products that are interrelated.

Little evidence is available to support or deny the assumption of between-product demand independence. It is important to note that production interactions between resource products to not create benefit interactions, they

create cost interactions. Similarly, demand or consumption interactions do not create cost interactions, they create benefit interactions. It is assumed here that these benefit interactions occur only within functional areas and not between them.

Analysis techniques that can generate demand functions are only partly available. Most uses of wildlife and fish (consumptive and nonconsumptive) that are recreational can be analyzed to generate demand functions. Other, commercial uses may be analyzed with market information in the form of equilibrium prices. Existence values and option values for such things as rare and endangered species is considerably more difficult. Theoretically tenable methods for empirically deriving demand curves for such commodities are very difficult at this time (Schweitzer 1981). The RPA National Assessment of Wildlife and Fish provides an example of the kind of data currently available about demands for wildlife and fish (USDA Forest Service, 1980).

Two methods of defining recreation demand curves are identified as theoretically tenable in the literature (Knetsch and Davis 1972, O'Connell 1977). The first is the travel cost method which utilizes travel costs to identify willingness to pay associated with different levels of recreation use (quantity demanded). The state-of-the-art for this method is presented in Burt and Brewer (1971). Some theoretical problems persist, but the major problem appears to be application of the method on a large scale without incurring exorbitant research costs. Three possible approaches to solve these problems include; 1) a representative site approach where a reasonable number of sites that are judged to be "representative" could be analyzed and the results applied to all "similar" sites across the country; 2) a national survey approach which could be used to regress demand curves for "types" of sites or activities; and 3) a

regional approach that would analyze all relevant sites across the country, but in groups according to location (this third approach would undoubtedly be the most comprehensive and the most expensive).

The second tenable method, the "bidding game," surveys respondents and, by putting them in hypothetical market situations, elicits a response of how much they would be willing to pay for various quantities demanded if they actually had to. The state-of-the-art for this method is presented by Brookshire and Crocker (1979) and Randall, Ives, and Eastman (1974). Application of this method might best be accomplished by population-based surveys at either the national or regional level. Because this method is hypothetical in nature, use of the travel cost method might be preferred whenever it is feasible.

In either method, a considerable amount of new data is needed. Efficient design of this data collection is critical to accomplishing the task with reasonable cost.

Costs

Two types of costs need to be considered: single output costs in each functional area, and joint costs for the integrated resource analysis. If, for example, a management strategy S was implemented on a given area of land, a vector of outputs would be produced. If S cost, say $1000 to implement on this area of land, then the cost of the output vector (ignoring land costs) would be $1000. Assignment of this cost to any one particular output would be arbitrary.*

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*The problem of allocating joint costs to individual outputs is well-recognized in the literature. For example, Herfindahl and Kneese (1974, p. 290-1) state; "In the case of cost allocation where products are jointly produced by the same facilities, no conclusive results appear to be possible, even in principle...The history of cost allocation is characterized by a long, and unsuccessful, search for a rigorous or theoretically sound method."

Thus, a "joint cost" of $1000 is the only tenable cost figure in an integrated context. This joint cost occurs because the managed forest and range is a joint production system.

A method of obtaining joint costs for any given set of outputs is through analyses currently performed in land management planning, state resource planning or other such planning efforts where management strategies and their attendent costs are developed. Individual resource management cost data for wildlife and fish is therefore not part of the information needed in integrated national assessments.

A Model Structure for Analyzing Planning Alternatives

A number of multiresource linear programming models have been used and are being used in forest resource planning (RCS, MAGE5, FORPLAN, and others). How this type of model is used in analyzing Forest Service planning alternatives is discussed in detail in the technical requirements for a national assessment of multiresource interactions (Hof and Hoekstra, 1982). A simplified linear programming model considering only two types of land, five management prescriptions, and three resources will be used to illustrate the general idea of how these are structured (D'Aquino 1974, Kent 1980).

This overly simple model example in Figure 1 ignores time dimensions and other complexities such as social impact constraints and nonconstant benefit coefficients. Environmental quality indexes are also excluded from the example. These complexities can be brought into the analysis without major difficulty--though such a model would be significantly larger (i.e., more rows and columns), and data problems are often encountered with such complexities.

In Figure 1, the major column headings are types of land and/or resources. The "X_i's" under the two land types are the number of acres allocated to alternative management prescriptions which could be applied in TYPE I (X_1 and X_2) and TYPE II (X_3, X_4, X_5) land.

Figure 1.--A simple resource allocation model where X_1 and X_2 are the number of acres in Type I land allocated to alternative management prescriptions: X_3, X_4, X_5 are the number of acres in Type II land allocated to alternative management prescriptions; X_6, X_7, X_8 are timber, wildlife, and forage products, respectively; the A_{ij} are production coefficients; the $A_{10,j}$ are the objective function coefficients; and the K_i are the right hand sides (RHS).

The timber, wildlife, and forage rows in the matrix represent the resource outputs of this land system which result from implementation of the management prescriptions. The land, TYPE I and TYPE II, rows are the inputs (acres) to this "joint production system." K_5 acres of Type I land are available, and K_6 acres of Type II land are available.

The timber output, wildlife output, and forage output rows are the amounts of each of the outputs that are harvested from the land system. The "Net Ben." row is the objective function which managers seek to maximize given the resources available and the production relationships involved.

The "X's" under the major column heading PRODUCTS ($X_{6,\ 7,\ 8}$) are accounting columns which collect and possibly transform the outputs into an aggregate output for the area being analyzed.

The A_{ij}'s in columns 1-5 can generally be termed the impacts of the j^{th} management prescription on either the ith row outputs or inputs. For example, $A_{1,1}$ is the output of timber per acre if the first management prescription is implemented on that acre, and $A_{5,1}$ is the amount of Type I land utilized (in this case, one acre). The coefficients in row 10, the "Net Ben." row, describe the change in net benefits if one unit of the j^{th} management prescription or product enters solution. Thus, $A_{10,1}$ is the cost of prescription X_1 and $A_{10,6}$ is the net benefit derived from one unit of timber output (X_6). K_4 is an upper limit on the amount of money to be made available for managing the area. K_7 through K_9 are output targets for timber, wildlife, and forage.

The solution to this maximization problem simultaneously determines the regime of management prescriptions applied to different land areas and product mixes that maximize the given objective function.

Production Information

Figure 1 depicted a production matrix structure. This matrix simply indicates that the production information required for any given "type" of land in future assessments is the expected outputs of timber, range, wildlife, fish, recreation, water, and ecosystem condition effects under different potential management strategies. This production matrix, as organized, could provide the primary method of linking wildlife and fish production with other resources for an integrated multiresource analysis.

Each row in the production matrix can be determined separately (in individual resource analyses) only if three assumptions hold:

(1) The same set of potential (or alternative) management strategies[1] are analyzed in each row. Unless this is true the matrix will be incomplete. Traditionally, analyses of single resource outputs have concentrated only on management strategies that are directly oriented towards that single resource. In order for the individual resource production analysis to be utilized in an integrated fashion, a set of alternative management strategies must be developed for all resources. Therefore each individual resource analysis must identify the production response to all of the potential strategies. These production responses may be zero or negative in those cases where the management strategy is actually oriented toward other resource outputs;

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[1]Management strategies are a combination of scheduled management practices.

(2) The land and water geographic unit upon which the production matrix is based is the same for all individual resource analyses (for all rows). This is necessary because the potential management strategies must apply to a given "type" of land that will have particular production responses. Empirically, a different production matrix would have to be derived for each "type" of land. In order to complete each of these matrices, each individual resource analysis (defining one row in each matrix) would have to be based on the same set of land types;

(3) The entries in each row are determined solely by the management strategy, and are not affected by the entries in other rows. This is necessary since each individual resource analysis will not be privy to the expected outputs of other functional areas. If various combinations of outputs are possible under a given management strategy, then the production matrix is structurally inadequate. It may, however, serve as an approximation.

Given these three conditions, each row in the production matrix is separable and independent.* That is, the production information in each row is unaffected by the information in other rows, so each row can be identified separately and independently by individual resource analyses. The first two conditions can be met through design of the analysis, but the tenability of the third condition is determined by the nature of the biological production unit. Violation of this third condition potentially could be ameliorated by iterative revision of the individual resource output (row) estimates as they are "put together" in the matrix.

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*It should be noted that column separability and independence is required by the nature of linear programming.

CONCLUDING DISCUSSION

Three technical requirements for National RPA Assessments were used to defined the task of conducting a national assessment of wildlife and fish. These technical requirements provide a basis for both individual and multiresource interaction aspects of an assessment of wildlife and fish.

The first requirement, for current and historical inventory information, has been the major contribution of past assessments. It will continue to be an important attribute of future assessments for providing an individual resource prespective. Consideration of how information used in this first requirement also will be used in the second and third requirement will facilitate the overall assessment process.

The second requirement, for inventory and consumption projection information, is a substantial increment beyond the first requirement in terms of both data and analysis. For wildlife and fish resources it is a requirement that has not been adequately fulfilled in previous assessments. Difficulties remain in the analysis of consumption projections for wildlife and fish. Inventory projections have not traditionally been used in wildlife and fish, however, marketed and recreationally used portions of the resource have sufficient data and analytical methods to provide useful and accurate information for inventory projections.

National assessments of wildlife and fish conducted to date have not been able to provide the comprehensive statement necessary to effectively make decisions about alternative future resource management situations used in requirement three. Such comprehensive statements as described in this paper are difficult analytically and lack necessary data except on National Forests. The requirements are not presented with the expectation that they could be accomplished on all ownerships in the short term. Rather, they are presented to provide wildlife and fish biologists with a perspective of what is needed in the long term for integrated resource assessments.

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